Barriers Faced by Coding Bootcamp Students

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ABSTRACT

Coding bootcamps are a new and understudied way of training new software developers. To learn about the barriers bootcamp students face, we interviewed twenty-six coding bootcamp students and analyzed the interviews using the *Communities of Practice* framework. We found that bootcamps can be part of an alternate path into the software industry and they provided a second chance for those who missed computing education opportunities earlier, particularly for women. While bootcamps represented a second chance, students entering the industry through bootcamps faced great personal costs and risks, often including significant time, money and effort spent before, during, and after their bootcamps. Though the coursework of bootcamps only ranged from three to six months, career change could take students a year or more, with some students even attending sections of multiple bootcamps.

CCS CONCEPTS

•**Social and professional topics** → **Computing education**; *Employment issues;* Adult education;

KEYWORDS

Coding bootcamps; computer science education; career change; communities of practice

1 INTRODUCTION

Demand for software developers is expected to grow 17% in the US between 2014 and 2024 [3]. In response to this, more people are graduating from undergraduate computer science (CS) programs (Figure 1), while others are learning software development from online tutorials, Massive Open Online Courses (MOOCs), and now fast-paced coding bootcamps [1, 17]. Coding bootcamps have grown rapidly in the US and Canada since 2013 (Figure 1) and serve a different population than undergraduate programs [19].

In spite of the growth of bootcamps, we know little about the barriers bootcamp students face, as previous reports on bootcamps have only focused on the logistics of bootcamps [18, 22], or the demographics and success rate of their graduates [19]. Research in computing education and career change suggests several barriers bootcamp students might face. For example, in various computing education contexts (high schools, colleges and universities), societal pressures cause divisions in who is encouraged to use computers and who is made to feel welcome in computing classes, in particular excluding female, black and latino/a students [2, 5, 12, 13]. In computing classes, students face stereotypes of what it takes to be a "real" programmer [5, 10, 12, 13] and those who feel belonging, comfort and confidence are better able to succeed [21, 27]. Similarly, people changing careers face barriers of confidence, gender, age, and educational level [4, 15, 20] while also facing pressures due to lost income and the effect of lost income on family [15, 20].

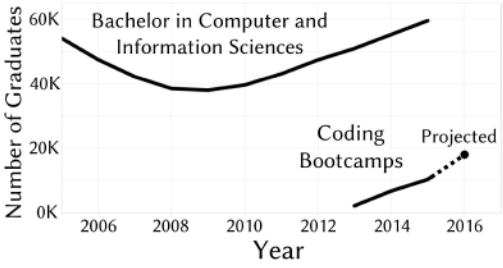

Figure 1: Yearly US bachelor in computer and information science graduation rate (by end of academic year) [14], along with yearly coding bootcamp actual and projected graduation rate in the US and Canada [18].

We hypothesized that the barriers faced in other computing education and career change contexts would also be faced by bootcamp students as they went through bootcamps and sought jobs in the software industry. We therefore interviewed 26 current and former bootcamp students to ask about their stories and the barriers they faced. Our participants represented eight bootcamps and a range of trajectories and stages, from early in a bootcamp to having finished. After considering frameworks for learning [8, 9, 24] and career change [20, 23], we decided to analyze our data with *Communities of Practice* [24] and concepts from the career change literature.

2 RELATED WORK

2.1 Communities of Practice

Communities of practice are "groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" [25]. These communities can range from formal such as a work team in an office, or informal such as a clique of students. We considered each bootcamp as its own community of practice and software industry jobs as communities of practice tied together in a *constellation of practice* [24].

The *Communities of Practice* framework [24] provided several useful concepts for analyzing and framing our results.[1] Communities of practice have community defined *boundaries* (both *formal*

[1] Since Wenger[24] rarely includes formal definitions of his terms, we provide our own.

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like member lists and *informal* like specialized jargon) which define what is *inside*, *outside* and at the *periphery* of the community. For joining a community, these boundaries must be *negotiated* with the community and are one type of barrier to entry. An individual's relationship with a community evolves over time as part of their *learning trajectory* [24]. As individuals belong to multiple communities of practice simultaneously, they face conflicting meanings and practices. The *Communities of Practice* framework has been used to understand the design of schools and businesses [24], apprenticeships [9], career change [26], involvement in Open Source communities [28], identity formation [16], and course design [7].

2.2 Barriers in Career Change

Another concept we used for analyzing barriers was *personal obstacles*,[2] which came from the career change literature. People changing careers face *personal obstacles* that include age, gender, financial considerations around temporary lost income (especially when they had dependent spouses or children), education level, personality and confidence [4, 15, 20].

2.3 Barriers in Computing Education

Previous studies on barriers in computing education have mostly focused on barriers students face in choosing and continuing CS studies in high school, college and university settings. In *Unlocking the Clubhouse* [13], Margolis and Fisher found barriers for women in undergraduate CS that included admissions (*formal boundary*), gender divides in computer use from a young age, stereotypes of who a "real" programmer is (e.g., anti-social), expected background experience and a belief in a "natural" ability to understand computers (*informal boundaries*). They also found women faced barriers of lost confidence and lack of social support (*personal obstacles*). *Stuck in the Shallow End: Education, Race and Computing* by Margolis, Estrella, et al. [12] examined the racial gap in high school CS, finding barriers that included lack of access to classes (*formal boundary*), cultural expectations on who the classes were for, feelings of isolation in classes, divisions within classes between those who "have it or don't have it" (*informal boundaries*), and lack of social support (*personal obstacle*). Additional studies found participation and success in computing programs depended on background experience [2, 27], comfort level [27], sense of belonging and stereotypes (disproportionately negatively affecting women) [2, 5, 10, 16], view of self as an "insider" [21], and believed role of luck [27].

In addition to these studies, there have been posters, marketing reports and commissioned reports on bootcamps [11, 18, 19, 22]. In the US and Canada in 2016, bootcamps had an average tuition of $11,451 and length of 13 weeks [18]. Bootcamp graduates were diverse in backgrounds (54% had previous full-time employment and 40% had never programmed before) and diverse in gender (43% were female, compared to the 16% of CS graduates) [19]. A report on international bootcamps briefly mentioned students may face *formal boundaries* (admissions, payment, and graduation), *informal boundaries* (gender), and *personal obstacles* (intensity, time, location, and family support), but it didn't provide details [22].

[2] *Personal obstacles* is our term combining "personal factors" and "obstacles" [15, 20].

3 METHOD

To study barriers in bootcamps and the software industry, we interviewed current and former students of bootcamps, focusing on bootcamps in the Puget Sound area (Washington, USA). We defined coding bootcamps as non-university programs that offered full-time, in-person, short-term (months-long) software development training. This excluded weekend, night, and part-time classes, strictly online bootcamps and any program that takes more than one year. We also excluded bootcamps that were not primarily targeted for software engineering jobs (e.g., data science, UX).

We found an initial group of bootcamp students through personal connections, LinkedIn, and a weekend programming class. From there we used stratified snowball sampling to find a range of bootcamp students. We focused on recruiting participants from different bootcamps, at different stages (*in bootcamp*, *post-bootcamp*, *job hunting*, *in job*, *no longer searching for a job*), as well as diversity in race and gender. We conducted 26 interviews and had at least two students from each of six full-time bootcamps in the Puget Sound area: Ada Developers Academy, Code Fellows, Coding Dojo, Dev Bootcamp, Galvanize, and General Assembly, as well as one student each from two out of state bootcamps. We had at least ten females and eight males.[3] We had students who were Black, White, Asian, Latino/a, and at least five who were more than one race or ethnicity. The youngest participant (who we know the age of) started a bootcamp at age 18, and the oldest at 39. We also interviewed students who identified as straight and as gay.

We developed a semi-structured interview protocol consisting of twenty-five questions divided into four sections: *background*, *deciding to attend a bootcamp*, *changes in views and goals*, and *how they perceive their experience in relation to others'*. We piloted and refined the questions with the help of someone changing careers into the software industry, though not through a bootcamp. The length of the interviews ranged from 24 to 94 minutes with a median length of 43 minutes. After completing the interviews, we transcribed them, removed personally identifiable information, and deleted the recordings.

From the interviews, we created chronological *coding bootcamp trajectories* and *software development trajectories* for each participant. We categorized the pieces of each trajectory by how they related to the community of practice. We then coded all discussions of *formal boundaries* (e.g., admissions, graduation, and hiring), *informal boundaries* (e.g., fitting in, unstated expectations, and group dynamics) with respect to the two communities of practice. We also did this for discussions of *personal obstacles*, which we defined as obstacles to negotiating community boundaries that were not concerns of the community (e.g., personal financial burdens and relational costs). We then synthesized the results in each category.

4 RESULTS

Because the coding bootcamp students we talked to viewed entering the software industry as their high-level goal (with bootcamps as a means to that end), we first discuss students' software industry trajectories and then discuss how students' bootcamp experiences

[3] We did not ask for demographic information in some interviews. For those, we counted any statements participants made which stated or implied their demographics.

related to these trajectories. We include quotes throughout, selectively omitting identifying information to preserve anonymity, and making minor edits for clarity. Any emotions reported are those explicitly stated by participants.

4.1 Participant Learning Trajectories

4.1.1 Software Industry Learning Trajectories. For each participant, we mapped each step of their *software industry trajectories* chronologically using the following four levels of involvement in the software industry: *unrelated activities* (e.g., other education, jobs), *preparation to enter the software industry* (e.g., classes, bootcamps, building a portfolio), *partial employment as a software developer* (e.g., contracts, internships), and *full employment as a software developer* (the stated goal of all participants).[4] Figure 2 shows the variety of our participants' trajectories. For example, participants P1, P2 and P3 went from unrelated education and careers into full employment while P26 returned to their former career after failing to get employment as a software developer. Nineteen participants took online courses, ten took separate in-person classes, and P5, P8 and P13 had degrees in CS before starting a bootcamp. Participants P18, P22, and P23 attended more than one bootcamp and participants P13, P14, P15, and P24 did not finish a bootcamp and had no plans to. Participants P19, P20 and P21 went to a bootcamp that had a built-in internship.

4.1.2 Coding Bootcamp Learning Trajectories.[5] Since the stated goal of coding bootcamps was to prepare students for entering the software industry, students' trajectories through bootcamps were a part of their trajectories into the software industry. Because of this, most students' bootcamp trajectories appear much like the first half of their software industry trajectories, so we do not show them here. Some students took actions to prepare for the software industry before starting a bootcamp, which incidentally also helped prepare them for their bootcamps. Other students prepared specifically for bootcamps, including P22, who attended the intro section of one bootcamp in order to improve their chances of getting into another bootcamp. While attending bootcamps, some students felt the tests, assignments and even bootcamp graduation did not align with their software industry trajectory. Because of this perceived misalignment, P25 took a break from the bootcamp to study more, P13 quit their bootcamp, and P6 suggested ignoring some bootcamp content and deadlines. After graduating from a bootcamp, some students continued to be involved through residencies (free space and time for building portfolios), paid TA positions, and alumni networks.

4.2 Barriers in the Software Industry

Having seen students' diverse software industry and bootcamp trajectories, we now focus on the boundaries and personal obstacles they faced in the context of their software industry trajectories.

4.2.1 Formal Boundaries. Bootcamp students universally reported wanting a full-time jobs in the software industry. Getting

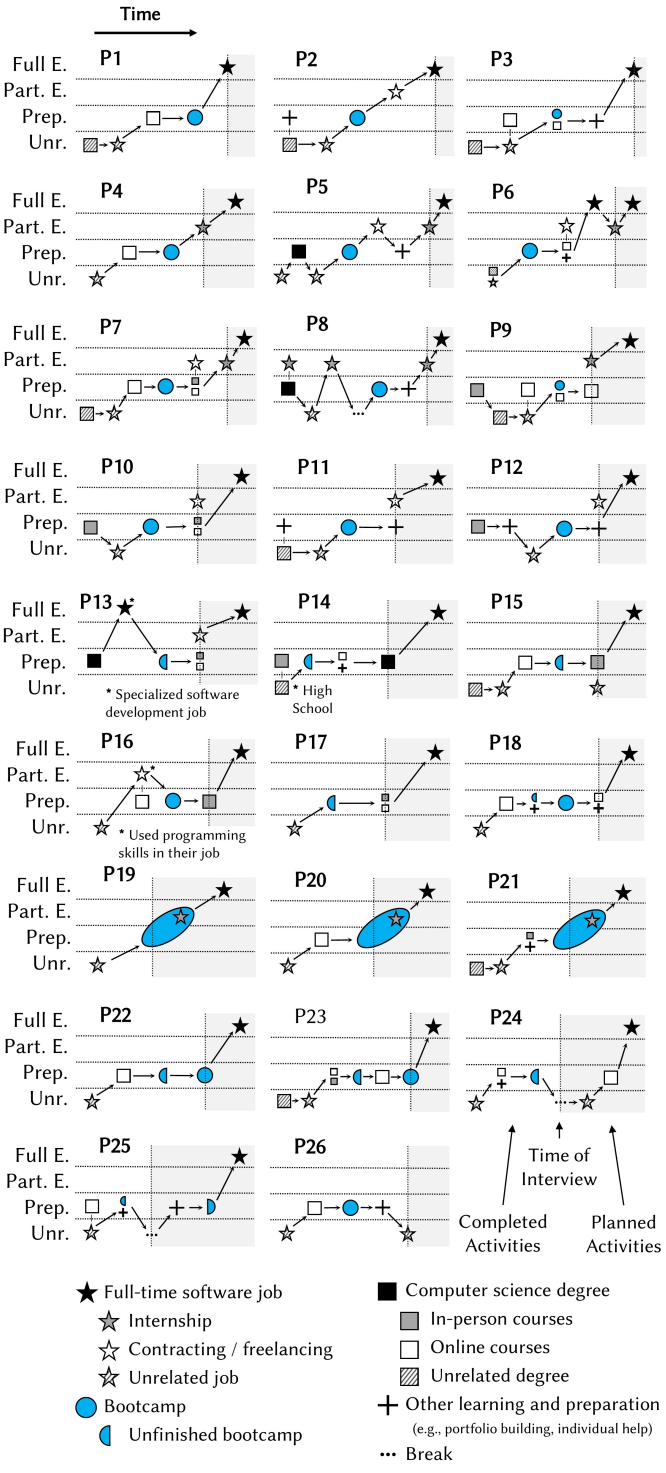

Figure 2: Software industry trajectories for all participants. Each graph show a participant's chronological activities in four levels of increasing software industry involvement: *unrelated* (Unr.), *preparation* (Prep.), *partial employment* (Part. E.), and *full employment* (Full E.). Participants are sorted by industry involvement at time of interview.

[4]Mapping the learning trajectories of our participants into these categories was mostly straightforward, though there were occasions where chronology was unclear.
[5]In discussing bootcamps, it should be noted that bootcamps are new and changing rapidly, with students mentioning significant changes in courses, content, and social dynamics between cohorts or even within their own journey through a bootcamp.

these jobs meant getting and passing job interviews. In their attempts cross these boundaries, four of our participants mentioned not understanding why they passed or failed interviews. This uncertainty was compounded by interviewers being unwilling to share their decision making process. As P5 said:

> [The problem is] not understanding what I'm doing wrong. [...] I would ask [interviewers], "Please give me feedback. What can I do better next time?" But I wouldn't get a response.

In spite of some uncertainty, bootcamp students mentioned several key factors in getting and passing job interviews.

The first was relevant educational credentials. While three of our participants had degrees in CS (bachelor's or associate's), the rest did not. Some of our participants chose to attend a bootcamp as a way of getting relevant educational credentials that would help with job interviews. P6 believed their bootcamp did just that, but several of our participants felt that bootcamp certificates were looked down on by employers. P3 said there was a "stigma" against bootcamp certificates and P26 explained:

> [I thought bootcamps] represented a vocational training standard, that it's somehow equivalent to going to nursing school and getting a certificate that says, "I'm qualified to be an entry level nurse." [...] It simply doesn't work that way.

Second, bootcamp graduates talked about the need to get initial software industry work experience (six participants describe this with a version of the phrase "get a foot in the door"). To get initial experience, some bootcamp graduates found paid contracting work and internships. Six participants were in internships and three were in a bootcamp that included internships. We believe our data overrepresents internships since several participants were recruited through others in the same internship and we heard little else about internships besides how most were not open to bootcamp graduates (P16 said, "A lot of the internships [...] only want college-aged computer science students.").

Third, several of our participants mentioned the importance of online portfolios in getting a job. Some said their bootcamps gave them enough time, knowledge, and projects for their portfolio, while others used additional time and effort after graduation.

Fourth, in order to find job openings and meet recruiters, our participants talked about the need to network by going to tech meetups and hackathons, applying for jobs, and using LinkedIn and bootcamp Slack channels. P8 had a programming background, but chose to attend a bootcamp in part for the networking and P3 believed networking made a large difference in getting a job:

> Some people were always behind in their coding, but they got jobs straight away because they had the networking connections.

Fifth, our participants emphasized the importance of interviewing skills, especially the skill of "whiteboarding" (eight students used a variation of that word) an interview technique, often requiring knowledge of data structures and algorithms. Some students approved of the whiteboarding training at their bootcamps, while others felt they needed more practice than their bootcamp gave them. Students used a variety of methods to get more whiteboarding practice, from online courses, to whiteboarding practice meetups, to non-bootcamp in-person classes.

Besides whiteboarding skills, several of our participants mentioned soft skills interviewers were looking for. P10 mentioned needing to be "a cool person," and P1 listed several specific factors:

> I felt when I was in interviews they were saying that they want someone with strong communication skills and someone who's easy to work with, a team player, who took instruction well.

4.2.2 Informal Boundaries. Our participants' discussion of informal boundaries fell into three categories: *knowledge*, *identity*, and *belonging*. The *knowledge* expected of a software developer included "learning to learn," meaning the ability to learn new programming languages and libraries from documentation, tutorials, and websites like StackOverflow. Twelve students mentioned this concept. P7 said this was the skill they wanted out of a bootcamp and most said this was something their bootcamp taught them, though P22 was annoyed with how this was taught:

> So they're trying to get you into this mentality of you have to read all the documentation. They sit back in the background [to let students read the documentation], and what annoys me is that I've paid a lot of money so that I could have somebody there to teach it to me.

Another piece of knowledge expected of software developers was knowing popular technologies and practices. P12 mentioned learning at their bootcamp about programming tools like Git and Slack, while P22 said they went to a bootcamp because they "wanted to learn the technologies that are up-and-coming."

The second category of informal boundaries was *identity*. Some students said they had difficulties in claiming an identity as a software developer and felt *impostor syndrome*.[6] Impostor syndrome was mentioned by seven of our participants (though one said they didn't struggle with it). One student (no CS degree) said that even after working as a software developer for about six months, they "still don't feel like an established developer." P2 said their bootcamp encouraged them to publicly claim the title of "web developers:"

> At the end of the first week they said, "Bring up your LinkedIn profiles [...] and change [your title] to web developer." And we're all like, "What? You've got to be kidding me. We're not web developers yet." And her point was that until you start thinking of yourself as one, then nobody else is going to.

The third category of informal boundaries was *belonging*, or fitting in among software developers. This included needing to know "the terms that interviewers are looking for," (P7) and handling "the social aspects that allow you to be a part of this group" (P5). One of the most mentioned aspects of fitting in was the lack of women. One participant (male, CS degree) said his current work environment was "all white dudes." Another participant (female, no CS degree) worried about how to handle a male-only work environment:

> In an actual job [when] I'm the only woman on the team, how do I do that?

[6]Impostor syndrome is when someone falsely believes that they are not competent and that they have fooled anyone who thinks they are [6].

Several participants said gender dynamics played into why they did not learn software development earlier. One participant (female, no CS degree) said:

> I never thought when I was younger that women could be programmers. That's just something that everybody knew, I guess.

Another participant (female, no CS degree) said her bootcamp provided a second chance to become a software developer:

> I'm a good example of somebody who easily could've gotten into this field the first time around. When I was in college [...] it just wasn't floated as something I could do. Nobody ever said, "Oh, you can't be a computer scientist." But nobody ever said, "Oh, you can be a computer scientist," either.

Race also came up as an element of fitting in. One Black participant (female, no CS degree) mentioned the lack of diversity at her current company:

> Especially at [my company], I felt like a lot of the software engineers I had seen are white or Indian or Asian. I see very few women, I see very few black people, so it's hard,

An Asian participant (male, no CS degree) said he was used to being a minority, but in the "programming world [he] wasn't a minority anymore," and a Latino participant (male, CS degree) said his race was less of an issue in Seattle and in the software industry than in his hometown:

> [In my hometown] it always felt like [...] I was just the brown guy. [...] Coming out here, people are a lot more open minded and they don't care what you are, they just care what you're doing.

Besides race and gender, the perception of software developers as nerdy or intelligent played a role in fitting in. P25 said:

> I started [learning to code] online. But it was so foreign to me that I'm like, "Okay, these are just for nerdy people. There's no way I'm gonna be able to."

Similarly, P2 perceived back-end programmers as "really technical people who eat Linux for breakfast," and then was surprised to find they also enjoyed back-end programming.

For others, the perceived nerdiness and intelligence of software developers was a desirable feature. One (female, no CS degree) had negative experiences with the online gaming culture, and needed to "start learning if [the software industry] is a community I can stand." She said:

> When I actually went [to a tech meetup, the fact that I was new] wasn't any kind of barrier, [...] people were actually supportive.

P16 felt similarly about meeting software developers:

> You know, when I went to a lot of events before I started bootcamps, I thought, [...] "I feel like I fit in with the curiosity and, for the most part, level of intelligence," even though I didn't have any of [programming] skills yet.

4.2.3 Bootcamps' Role in Negotiating Boundaries. Bootcamp students had to negotiate both formal and informal boundaries in the software industry, and our participants expressed different views on how attending bootcamps contributed to this process. Some participants believed their bootcamps were successful in getting them what they needed to know, such as P4:

> I would say that going to [my bootcamp] was probably the best decision that I've ever made [...]. Going from not knowing anything about coding [six months earlier] to being here today is pretty ridiculous...I love [my bootcamp].

Some were upset with their bootcamps. P12 said some from their cohort "want[ed] to do a class action lawsuit," and P26 said, "if I were able to do it all over again, I absolutely would not go."

Others had mixed feelings, such as P16, who said bootcamps and other classes were "just steps along the path [into the software industry] that every person has to find," and another participant (male, CS degree), who said:

> I feel very confident being able to get a job now. And I do attribute it to how things went while I was at [my bootcamp]. But [...] I withhold some judgment on how good [my bootcamp] is at producing employment for people on a broader scale.

Several students were skeptical of the success rates their bootcamps advertised. One (female, CS degree) questioned whether contracting work was being counted as success and P11 said their contracting work was announced as successful employment. One bootcamp had a (later discontinued) job guarantee program with strict requirements which one student (male, no CS degree) missed at the end. Another student thought these strict requirements were used to make the bootcamp success rate look better.

4.2.4 Personal Obstacles. Bootcamp students also faced *personal obstacles* in entering the software industry. Most of these personal obstacles stemmed from the time it took to transition into the software industry. While a number of students told us they chose bootcamps because they provided a faster route to a job than a degree, many still found time to be an obstacle. Students could spend a year or more when including the time spent learning programming before their bootcamp, or learning more and seeking full-time jobs after graduation (Table 1)[7]. Many felt their bootcamps had not communicated accurately about the time needed. P16 said, "I wish I had known before I started [the bootcamp] that it could take a really long time." In addition to losing time in the career change process, the career change also could mean loss of previous career and educational investments, like P9 said:

> I knew if I went into coding, I would be making my bachelor's degree obsolete. And that was a hard thing.

Financial costs were a personal obstacle for students trying to enter the software industry. These costs came from bootcamp tuition and prolonged unemployment. P1 said, "the cost became more of an obstacle after graduation, when I was on the job search," and another participant (male, CS degree) said he was surprised by this cost:

> When I [started the bootcamp, I] was really surprised [that after] almost four months [...] there was a decent number of [the previous cohort] still not having jobs. [...] I certainly hadn't factored that into my finances.

[7]Our participants did not always tell us how much time they spent on different activities, particularly with activities before bootcamps.

Table 1: Times spent before and after bootcamps

	Time spent before bootcamp	Time from graduation to job		Time from graduation to our interview (no job)	
	Classes (no CS degrees)	Full-time job	Internship	With some contracting	With no contracting
Time Range	3 months - 6 years	2 - 5 months	0 - 1.5 years	3 - 12 months	1 week - 9+ months
Median Time	9 months	2 months	1 week	5.5 months	2.5 months
Participant #s	9, 16, 20, 26	1, 2, 3, 6,	4, 5, 7, 8, 9	10, 11, 12, 13	15, 16, 17, 18, 26

These financial obstacles were mitigated in various ways. Some participants had a spouse who supported them. One participant went back to part-time work after their bootcamp while continuing to study on their own. Bootcamps sometimes offered partial solutions through paid TA positions that graduates could take while they were job-hunting. Some students still struggled tremendously. P26, who could not find a job after attending, said:

> I have been so distressed by [the bootcamp and job search]. I have put everything on hold. My house is for sale. My whole life is in shambles because of this. The whole thing has pretty much derailed my career, derailed my life. I spent tens of thousands of dollars pursuing this.

Another participant (female, no CS degree) said:

> To be extremely honest, in choosing this path, I've come the closest to being homeless that I've ever been.

The obstacles of time and money could be compounded for those with families. One participant told us about the nine months following bootcamp graduation:

> I pretty much devoted my time to [my bootcamp's] prescribed job hunting methods, which means financially, I have no money. [...] And that [sacrifice] reflects on my family because now we're low on funds [...] and now instead of selling our house and buying a house, we're selling our house to pay the debt that we're in and then go rent until I can find a job.

In addition to time and money were several other obstacles. Finding support of family and friends was an obstacle for some, including one participant (female, no CS degree) who said:

> My friends and family [...] have known me until that point as nonprofit lady who did informal education and experiential education. So when I said, "I'm doing this program so I can be a software developer," they'd just look at me like, [...] "You doing tech? We just don't get it."

Location was another. Though some said the software industry opened opportunities to live where they wanted, others had to leave friends and family. As one participant (female, no CS degree) said:

> I love [my state]. I have a house there. And my husband's currently there. I wanna go back, but at the same time, [my internship in Washington is at] one of the top tech companies in the United States.

Another set of obstacles involved motivation. Several students mentioned the difficulty of maintaining focus while learning software development outside of a bootcamp. For example, P10 said:

> I didn't want to commit towards something that I wasn't passionate about, and regular school is boring. [...] I needed to go to a bootcamp, because it's going to keep me focused.

Motivation to persevere on the job hunt was an obstacle for some, like P5, who said they applied to 100 different jobs and P1, who described job hunting as "dehumanizing."

Finally, confidence was an obstacle for some students, which was previously discussed in terms of impostor syndrome in 4.2.2. For some students, attending a bootcamp increased their confidence, (P1 said "[My bootcamp] made me very confident about my ability to achieve the goals that I've set for myself as long as I work hard."), while others lost confidence in a bootcamp (P18 said, "My confidence went downhill after that month at [the bootcamp].").

4.3 Barriers in Coding Bootcamps

We now turn from the barriers students faced in entering the software industry to those they faced specifically in bootcamps.

4.3.1 Formal Boundaries. Formal boundaries in bootcamps included admissions, payment, co-location, and bootcamp stages. Admission to a bootcamp could be permissive (one student said their bootcamp had "no entrance exam or anything [...] they'll take literally anyone.") or strict, such as the first one P10 applied to:

> It's super competitive. The acceptance rate I think is 2% [...] I didn't get in, which is fine. So that's why I went to [another bootcamp].

After admission, all bootcamps required in-person attendance (at least for some sections of the bootcamp) and significant payment. One bootcamp had no tuition, but for the others, our participants mentioned prices from $10,000 to $20,000. Some bootcamps offered scholarships and some allowed students to pay partial tuition for only attending part of the bootcamp. During the bootcamp, courses or stages were formal boundaries marking progress. Some bootcamps had tests that had to be passed in order to advance. When students graduated, they could stay involved through alumni networks, residencies, and TA positions.

4.3.2 Informal Boundaries. Informal boundaries within bootcamps were often similar to those in the software industry (4.2.2), particularly those of race, gender, expectations around knowledge, impostor syndrome and the perceived "nerdiness" and "intelligence" of software developers. For example, the demographic makeup of many bootcamps had a lack of women and minorities like the software industry. P24 said that there were only two women in their cohort, and another (male, CS degree) described the ways his cohort was homogeneous:

> Almost everyone was in a really tight age band. It was a bunch of people that were 27 years old. Everybody

> was white. Everybody was middle-class, wealthy though there were a couple outliers. [...] The only way that [my bootcamp] was diversifying at all from the current demographic of people in software was there were a lot of women there.

On the other hand, some bootcamps pushed for more diversity. For example, one bootcamp only accepted women and people of non-binary gender, and at least two bootcamps had built-in training around diversity and empathy. One (female, no CS degree) explained how welcoming she felt her bootcamp cohort was:

> There are [many] of us that come from poor backgrounds. There are a number of us that are Latina. [...] [My bootcamp] is the first place where I felt that owning different identities and being different is okay.

A different kind of diversity at bootcamps was in students' relations to programmers. Though we did not specifically ask, we found that at least four students were married to programmers, and another seven had parents, siblings or friends who were programmers. One student (male, CS degree) said:

> Yes, [there are] women being involved in programming, but the women the bootcamps are drawing in right now are from the same social sphere as the current programmers.

As with diversity, the informal boundaries around perceptions of "nerdiness" and "intelligence" showed up in bootcamps. For example, P22 said they had difficulty relating to classmates who were gamers. Similarly, students mentioned feeling impostor syndrome in their bootcamps. In particular, several students mentioned their cohorts being divide into two groups. There were different descriptions of the divide based on one or more factors including effort, "being good at school" (P16), being "tech savvy" (P3), and seven people mentioned a divide based on "background" and previous "experience" with programming, such as P18:

> It was divided, the class. Those with experience, I think, they were looking down at [those of us without experience] because maybe there were certain things we were supposed to know and we didn't.

Another participant (female) saw this divide from the other side:

> A lot of [the other students] don't have the experience that I have. I have a degree in computer science, I have 10 years-plus experience in a job market. [...] A lot of people are coming from accounting, or something else completely unrelated [and] are probably are going to have a way harder time than I am.

This divide was difficult for some students. For example, P25 talked about a student who was having trouble and then quit:

> To me what was most sad was not the fact that he quit, [but that] he felt he was dumb and not smart enough to do it.

To cope with this divide, some students tried to reach out within their cohort, like P12 who hung out with more experienced programmers, even though they did not feel like they fit in with them.

Though some students talked about divided classrooms, other students mentioned group bonds that formed in their bootcamp. P5 mentioned making close friends at their bootcamp and P9 said at their bootcamp, "everybody knows what's going on with everybody else. It was a very close-knit experience."

One final informal boundary faced by students was access to teachers. While some participants at some bootcamps said their teachers were helpful and engaged with everyone, other participants felt differently, such as one (female, no CS degree), who said "I felt uncomfortable asking questions [of the teachers]." One (no CS degree) had a particularly bad experience with asking for help:

> There was this one time where my database wouldn't work because I hadn't capitalized a letter and I asked one of the assistant teachers about that and he thought it was ridiculous that I made a mistake about this capital letter.

Some participants saw bias in who their teachers spent time with. One participant (male, no CS degree) believed some women were getting extra attention and another (female, no CS degree) said extra help was "reserved for people who were on the upper-end of class." TAs provided a middle ground of access between students and teachers, though opinions ranged from, "It's very nice that we have TAs" (female, no CS degree), to "The TAs were not helpful whatsoever" (female, no CS degree).

4.3.3 Personal Obstacles. Many of the personal obstacles faced by bootcamp students in their software industry trajectories (4.2.4) overlap with those they faced in attending and succeeding in bootcamps, such as time, money, impostor syndrome, and location. For example, just as location was an obstacle for some jobs, one participant (female, no CS degree) moved away from her husband to attend a bootcamp.

The ways personal obstacles were unique in bootcamps revolved around what eight students described as the "intensity" of the bootcamps. The intensity started with a large percentage of students' weekly time spent on the full-time portion of their bootcamps.[8] One participant (female, no CS degree) said that the official weekly schedule of her bootcamp was eleven hour days, six days a week, while P18 talked of even longer days:

> Ten, twelve hours at least per day, and sometimes fourteen or sixteen hours [...] and no weekends because we had assignments.

This time spent gave our participants very little time to do other things in their life. One (female, no CS degree) talked about the resulting state of her home and hygiene:

> I did all my laundry this weekend, for the first time in like a month, because I was out of everything. My kitchen is a disaster. My whole house is just a mess. Anything that is not directly related to [the bootcamp] or to keeping me up and functioning, just goes by the wayside. [...] I don't remember the last time I had a shower.

The time spent at bootcamps added financial obstacles beyond just tuition and costs of living. Students were not able to hold jobs for full-time portion of their bootcamps and P9 said financial difficulties caused some people to drop out of their bootcamps.

The intense time commitment of bootcamps also meant students lost time with friends (P11: "I had to tell pretty much everyone in my immediate intimate circle, 'I'm probably going to disappear.' "),

[8] Some bootcamps were broken into stages and they allowed or required the early stages to be taken online or as night classes.

partners (P21: "My poor boyfriend. I see him so rarely.") and family (P12: "I didn't spend time with my family at all for a month."). Also, similar to the software industry trajectories 4.2.4, some students faced obstacles in getting social support for attending bootcamps.

The intensity and speed at which material had to be learned at bootcamps could be very stressful for students. P11 said everyone else in their cohort broke down and cried at some point and one participant (female, no CS degree) said how this affected her "brain power:"

> Sometimes I'm just so burnt out, I can't even think. I can't process. Somebody asked me, "What'd you have for dinner last night?" I'm like, "I don't know. I dumped all that."

To succeed in the intense bootcamp environment, several participants said students needed confidence, commitment, and determination. P2 said, "What's going to make or break your success [in a bootcamp] is how nice you are to yourself when you're frustrated." Another (female, no CS degree) got help from her husband:

> I learned more from coming home and my husband teaching me algorithms and how to approach a certain problem than [from the] teaching in class.

The intensity of bootcamps also had an effect on some students' health. Two students mentioned how their diet had suffered (E.g., P5: "When I first started doing this, I didn't really eat or drink too much.") and three participants mentioned their lack of sleep while attending a bootcamp. P12 talked about getting sick:

> When I was in college, when I got sick, I could take some time off. At work, I got sick and they'd rather me stay home. Here, when I got sick, I needed to still show up because one day of missing a class is a lot.

5 DISCUSSION

Unlike prior reports on bootcamps [18, 18, 22] our study is the first to explore the experiences and perspectives of bootcamp students.

Our investigation provided a long, chronological perspective of several adults' attempts to enter the software industry (Fig. 2), and showed how bootcamps provided a second chance. In particular, some women, as in previous research [2, 5, 13], either had not thought programming was something for them or had been scared off by the lack of women in CS. When attempting to enter the software industry through bootcamps, many of our participants, perhaps due to their independence and experience or because of misalignments between bootcamps and the software industry, made use of additional time and resources outside of their bootcamps or even attended sections of multiple bootcamps. For these students, bootcamps were just one step on a longer path to cross the formal and informal boundaries into the software industry, with the bootcamp providing focus, peers, networking and a set curriculum.

The informal community boundaries bootcamp students faced mirror prior work on computing education in high schools, colleges, and universities, such as those around race, gender, and previous experiences [2, 12, 13, 27]. Some, though, found different bootcamps (or cohorts) to be more open and inclusive. This could partially explain how coding bootcamps have achieved near gender parity [19] and may provide insights on how other computing programs can increase diverse engagement. Stereotypes of "nerdiness" and "intelligence" also formed informal boundaries for bootcamp students, as found elsewhere [2, 5, 10]. The class divide, largely attributed to previous experience, also matched other contexts [12, 13, 21].

Bootcamp students faced significant personal costs when attending bootcamps and changing careers. Some costs, like financial and family concerns, match what has been found in other career change contexts [15, 20]. Beyond those, the intensity of bootcamps and the career change time required significant perseverance and confidence, while leaving little time for relationships and self-care.

Though bootcamps offered more diverse graduates to the software industry, it was these diverse students who were taking on large costs and risks with few guarantees. Only one bootcamp had tuition covered by the industry, and several students doubted the success rates posted by their bootcamps. Additionally, students struggled with finishing their bootcamps, learning the material, knowing what was required to get a job, and a perceived "stigma" against coding bootcamp graduates. Some of our participants found full-time work despite these struggles (many were enthusiastic about their bootcamps), while others struggled or failed. These risks and costs may limit the diversity in background and financial status of those who attempt and succeed in entering the software industry through bootcamps. If coding bootcamps address the difficulties faced by their students and the industry takes on more of the risks and costs, then bootcamps have the potential to expand the pipeline into the software industry with more diverse talent, while personally benefiting many more students to come.

6 LIMITATIONS AND FUTURE WORK

Our research focused on a small sample of students in coding bootcamps in one part of only one country. Other students may have had different experiences, especially in other bootcamps, in other places, and in other times. Additionally, while our stratified snowball sampling provided a range of experiences, we can make few claims about the commonality of experiences or causality.

Our interviews were also limited. We did not ask for a full chronology of events, which may have left gaps in the learning trajectories, and students may have answered differently with a different interviewer (all interviews were done by a white male with a CS background). More perspectives would give further context on bootcamps, such as from classroom observations and the views of bootcamp organizers and teachers, and those making hiring decisions in the software industry. Additionally, our use of prior frameworks in analyzing results could distort student perspectives.

To further understand the role of bootcamps in meeting demand for software developers, our results suggest future studies in the quality and content of instruction, the structural inequities within bootcamps and the software industry, and the downstream differences in long-term careers between software developers with CS degrees and with bootcamp training.

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